Growing Blackberries Organically under High Tunnels for Winter Protection and Increased Production

Principal Investigator
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Project Duration
2010

Award Amount
year 1: $12000

Project Summary
Can organic blackberries be grown commercially in southwest Wisconsin? Scenic Valley Farms has been growing blackberries on a limited scale, and with limited success, using the labor intensive practice of tipping the plants and covering them with mulch for winter protection.

The project will determine if blackberries can be organically grown for commercial production in a zone 4a hardiness zone by using high tunnels with auxiliary heat. It will also determine whether high tunnels increase yields. Numerous blackberry cultivars have been planted under a high tunnel to determine their winter survivability rates and potential yields.

The original objectives of the project included:

(1) determine the viability of growing organic blackberries under a high tunnel for commercial production in a Zone 4 climate
(2) Research, record and evaluate the crop production processes required to grow organic high tunnel blackberries for commercial production
(3) Design a portable forced-air cooling system to provide post harvest management of the berries.

The Statement of Work, however, has been modified due to reduced funding for year 1 and lack of funding for year 2 and 3. The revised work plan now is limited to researching six varieties of blackberry cultivars in a 96' X 30' high tunnel. Additional tasks include displaying project information on the Scenic Valley Farms website, hosting field days in the fall, and preparing a season ending report.

During the project, the following data is being collected: branching, fruit weight, flavor, color, sturdiness, irrigation levels, soil and leaf nutritional analysis, fertilization requirements, propane fuel and electricity costs, disease/insect identification, insect and disease damage, blossom set dates, fruit harvest dates, and cane winter survival rates.

Scenic Valley Farms was started in 2008 in Readstown, WI and Rosemount, MN with the goal of growing blackberries for commercial production in a northern climate. Our company designs and manages high tunnels, semi and fully automated climate control systems, and subterranean solar thermal heating

systems. SVF maintains five semi-automated high tunnels that produce blackberries, raspberries and tomatoes.

Project Description

As part of the project, six varieties of blackberry cultivars were planted in a 96' X 30' high tunnel in Readstown, WI. For a separate project, two high tunnels were constructed in Rosemount, MN to test the viability of winter protecting both primocane and floricane blackberries. At this site, floricane varieties were planted in a 30' X 60' gothic style high tunnel and primocane varieties in a 12' X 40' PVC high tunnel. Although individually funded projects, the results from the two sites will be discussed in this report since they may be useful to growers in Wisconsin.

In 2009, we worked with Poly-Tex[1] of Castle Rock, MN and consulted with Terry Nennich to design a high tunnel suitable for blackberry production. Our requirements included straight side walls with sufficient height clearance to support a 7' trellis system; a gothic peak for optimal snow load capacity; and a price that is competitive with other high tunnels on the market. Using these specifications, Poly-Tex designed and developed the Field Pro high tunnel that is now installed at our farm in Readstown.

The semi-automated high tunnels are composed of sensors and controllers that monitor the crop production processes, thereby reducing on-site management and better facilitating the commercialization of blackberry production.

All the high tunnels employ in-line drip irrigation and Acclima moisture sensors to regulate irrigation and fertigation cycles. The emitters were spaced no more than 8 inches on either side of each bramble. In addition to moisture content as a percentage, the sensor provides soil temperature and EC. The controller has up to six zones controlling six values, each with six separate watering times.

We prepared the land for the high tunnels using black plastic to smother the weeds then fertilized the soil using well rotted horse manure and recycled mushroom compost. The plastic should be applied a minimum of 2.5 months before setting plants in the ground in order to properly destroy the weed seeds and rhizomes.

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[1]*Inclusion of a trade or business name does not imply endorsement of that product or business by the Minnesota Department of Agriculture, nor does omission imply non-approval.*

Figure 1: Site Preparation (Readstown)

Inside, the floricane high tunnels, we installed a wooden "T/V" trellis system to support the berry canes. We ran two strands of wire at the tip of each crossbar "T", for a total of 4 runs containing two wires each. The posts should be spaced 10 feet apart. Year 1 canes were tied to one side of the strand and they will bear fruit in year 2. After producing fruit, the year 2 canes will be pruned to the ground to make room for year 3 primocanes.

Figure 2: High Tunnel T/V Trellis System (Rosemount)

Figure 3: Drip Irrigation and Fertigation System (Readstown and Rosemount)

Figure 4: Acclima Moisture Sensor (Readstown and Rosemount)

The ventilation system consists of end doors, motorized side curtains, circulation fans, and gable end motorized ventilators. All of these systems are controlled using sensors.

Project Benefits

Blackberries offer several health benefits. Fresh blackberries are not only good to eat but contain beneficial antioxidants. Foods high in antioxidants help prevent cancers. Fresh blackberries were ranked #1 in antioxidant content per serving out of 1500 fresh and prepared foods in a study by Norwegian and US researchers published in the July 2006 issue of *The American Journal of Clinical Nutrition*.

Market research indicates an annual demand for one million pounds of organic blackberries in the Upper Midwest. We have received interest from several U.S. organic wholesale food distributors,

including Organic Valley Farms, Bergin Fruit and Nut Company, and Sun Belle Inc. We plan to produce 3 acres of blackberries under high tunnels, anticipating a yield of 30,000 lbs/acre/yr.

The lack of locally grown blackberries creates a tremendous opportunity for any grower capable of bringing blackberry production closer to major cold weather markets. The local, organic aspect of the blackberries, along with their exceptional taste and freshness, should be emphasized in any marketing campaign.

The mushroom compost was recycled from Songs Mushroom Farm (typically the compost is discarded in a landfill). The mushroom compost and the mulching practices reduce both water consumption and soil erosion. The moisture sensors also reduce water usage by suspending a water cycle when soil moisture content fails to drop below a preset level. Additionally, locally grown blackberries reduce the number of "food miles" compared to produce shipped in from places like California, Oregon, and Central America.

Project Results

As mentioned earlier, a Poly-Tex Field Pro 96' X 30' high tunnel was installed at the site. The manufacturer provides well written instructions and we recommend following them as closely as possible. When laying out the tunnel make sure to orientate the end of tunnel into the prevailing wind. Ideally, the side walls should be facing south to maximize solar radiation. Pound a single corner stake into the ground and use a 3-4-5 ratio to square the other corners 30' and 96' on center. Attach a string line at the desired top of ground post and another string line 6" beneath. Pound the remaining post approximately 2' in ground and 1' above ground. Other suggestions to make the construction go smoother include:

- Use string line and 1 ¼" tek screws set into stakes when sliding bows onto ground stakes
- Use tek screws to secure connectors to bows and end of purlins
- Duck tape all purlin connections at end of bows to prevent ripping of the plastic
- Use 1x6 pine boards for curtain and base boards and drill 1 ¼" tek screws to secure board to frame.
- Install u-channel and wiggle wire on side walls
- Install plastic on calm morning or evening (< 5 mph)
- Attach plastic to 5 -2x4 x12' lengths of lumber and pull over side walls
- Allow at least three hours of calm wind to secure plastic

The soil was amended by mixing in equal parts mushroom and dairy manure compost and applying one wheelbarrow per ten row feet. After, the compost was tilled into the soil using a hand rotor tiller. Once the canes were planted, we mulched each plant with a combination of mushroom compost and straw.

The floricane blackberry canes were planted in Rosemount on May 15th and in Readstown on June 10th. Both tunnels contain Triple Crown, Arapaho, Chester, Apache, Ouachita, and Natchez varieties. The canes were planted in four rows spaced at 7 feet, with the outer two rows 4.5 feet from the side walls. The plants are spaced 3 feet apart with 80 and 132 total in the Rosemount and Readstown tunnels, respectively.

Initially, the plants in Rosemount were provided 3 gallons per day per plant in two 1.5 hour cycles at 7:00 a.m. and 6:00 p.m. Once the primocane varieties began fruiting, the irrigation levels were increased to 4.5 gallons per day in three watering cycles. The brambles in Readstown were provided 4

gallons per day per plant in two 2 hour cycles at 7:00 a.m. and 6:00 p.m. On October 29th, irrigation levels were increased to 6 gallons per day per plant in order to provide extra moisture to the brambles throughout the winter when they would have no access to water. Frequently, the water moisture content of the soil failed to drop below the preset level of 40 percent, and the sensors suspended an irrigation cycle.

We used a one gallon EZ flow fertigation system and an organic fertilizer containing bat guano. The organic brands we experimented with were Algoflash, FoxFarm Big Bloom and Pure Blend Pro Bloom. It is not recommended to use fish emulsion as it has a tendency to clog the emitters. We plan to install drip tape next year in two rows of a single high tunnel and fertigate the plants 2-3 times per week. These two rows will have a separate moisture sensor, valve, and fertigation tank. Since the drip tape emitters are positioned closer together, however, we predict this approach will result in unnecessarily increased water and fertilizer inputs.

In order to control weeds, three techniques were employed. A layer of wood chips was spread on the PVC high tunnel floor. In the gothic style tunnel, we laid down sheets of cardboard before spreading wood chips. In a third high tunnel at our farm in Wisconsin, we rolled out 14-24 mil black polyester material in widths of 3 and 6 feet. The most effective technique appears to be the black polyester material, which also has the added benefit of controlling soil erosion and reducing labor.

Last winter, we pruned the primocane varieties (Prime Jim and Jan) to the ground in the smaller PVC high tunnel. Once the primocanes reached five feet in height, the canes were tipped and laterals supporting new blossoms began to appear within weeks. Continual pruning throughout the entire growing season generated new blossoms. Once they were tall enough, the floricanes were tied to the trellis wire (see above for description of technique) and tipped at 6 feet. The laterals were also tied to the wire.

The floricane varieties in Wisconsin were not shaded and as a result experienced higher rates of growth, more lateral development, and studier canes than the Minnesota varieties. In Wisconsin, the brambles averaged at least three extra hours of sunlight throughout the growing season.

The primocane high tunnel was partially shaded, with the west end wall receiving two hours of extra direct sunlight compared to the east end wall. As a result, the plants exposed to more sunlight had higher blossom counts and generated larger yields.

We also observed better growth with the root stock versus the culture stock. Interestingly, inconsistent growth of the same variety in the same high tunnel was frequently observed among the floricanes in both Rosemount and Readstown.

The floricanes displayed no visible signs of disease or pests throughout the growing season. This is typical during the first year when foliage development is relatively minimal. The second and third years have much higher incidences of disease and pest outbreaks and the brambles will be monitored closely.

The Arapaho variety had the highest rate of growth among the brambles, adding approximately 60 inches to its planting height. The other varieties averaged between 35-45 inches of new growth. A much fuller picture will emerge next year once the brambles have experienced a full growing season under the high tunnel. At that time, we will be better able to assess the attributes and deficits of the different varieties.

The primocanes began fruiting in early August. The individual fruit size averaged between 6-15 grams. The fruit was often difficult to pick at optimal ripeness because of its softness. The thorns also required that pickers wear gloves and flannel shirts. Once fruiting commenced, the bramble water demands increased (see above) and irrigation cycles were rarely suspended.

The weekly yields from the primocane high tunnel (12 Prime Jim and 12 Prime Jan blackberry brambles) are displayed in the graph below.

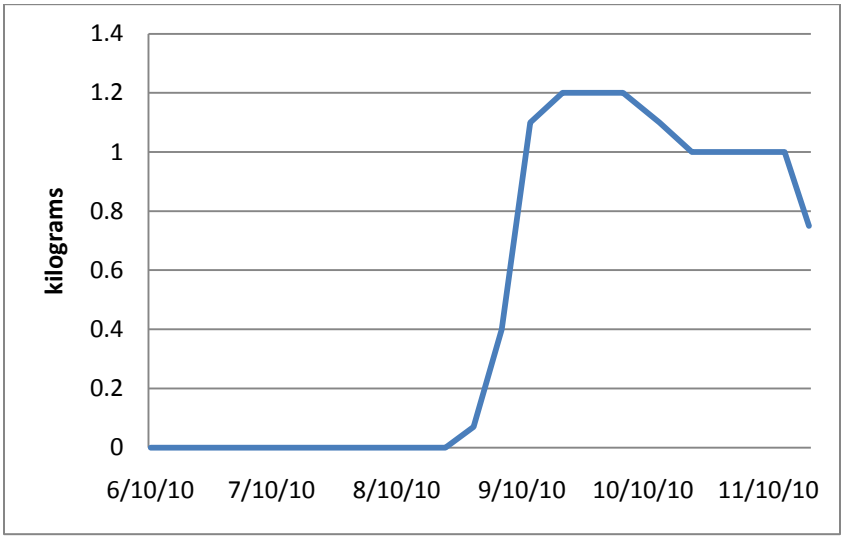


Figure 5: Weekly Primocane Blackberry Yields (Rosemount)

The major problem was maintaining temperatures inside the high tunnel at the optimal range of 80-85°F. Temperatures in excessive of 100° F prevented proper drupelet formation in some cases. This problem should be easier to remedy in the larger high tunnels because of their superior ventilation capabilities. In early September a small amount of the berries experienced Botrytis fruit rot due to cool and moist conditions. We started closing the tunnel at night to raise the temperature. The fungus mostly cleared up as the result of the warmer temperatures.

Due to a forecasted stretch of sub-freezing weather, the auxiliary heat in the primocane tunnel was suspended and the final harvest occurred on November 18th. After that date, the brambles were allowed to enter the dormant phase. It should be noted, however, that when the heat was suspended, the brambles still had significant amounts of both blossoms and fruit present. The photos below demonstrate the season extension capabilities of high tunnels when coupled with auxiliary propane heat (notice the snow on the high tunnel).

Figure 6: Primocane High Tunnel (Rosemount)

Figure 7: Photos taken on November 14th in Primocane High Tunnel (Rosemount)

Figure 8: Primocane berry cluster on November 14th (Rosemount)

The floricane high tunnel contained a few brambles that bore small yields (several berries or less per plant). The varieties that fruited were Chester, Apache, and Arapaho. Typically, floricane blackberries do not produce until the second year and no approximate cause was detected for these plants early yields.

The plants took a long time to freeze out in the late fall due to the increased warmth of the high tunnel. The snowfall in December also created an insulation effect and warmed the tunnel by 10-15°F compared to the outside temperatures. We installed a thermostatically controlled 170,000 BTU propane heater that is set to fire when the temperature drops to 5°F and turn off when temperatures reach 9° F. These are the minimum temperatures of a zone 7b climate. According to the temperature data loggers, the propane heater has not activated yet this winter (as of December 28, 2010).

In the early winter months, we experienced problems with rabbits entering a Rosemount high tunnel and girdling the canes. Roughly 10-15 percent of all the canes were either destroyed or badly chewed. Within two weeks, the rabbit would have destroyed all of the canes. Interestingly, the rabbit only attacked the thorn less floricane varieties, probably due to their freshness. We blocked off the possible entrances and set two traps inside. A few days later, a rabbit was found in one of the traps and we have not experienced any girdling since. The Readstown high tunnel is several hundred feet from any wooded areas and as a result has not experienced any issues with rabbits or other pests.

The plants were watered heavily before the irrigation system was turned off to build up a moisture bank for the brambles during the winter months. The lack of moisture throughout the winter is a concern and we will provide updates on how this affected the plants. The expected increase in temperatures inside the high tunnel in February is also a concern as it might promote premature budding.

Overall, the project has reduced labor and input costs. The moisture sensors provide automatic irrigation and fertigation in the high tunnel. The black polyester material and wood chips dramatically decreased the amount of time devoted to weed management. The major inputs of labor occurred

during site preparation and harvest (although even these periods were very manageable). The drip emitters reduced the amount of water required and the in-line fertigation provided precise amounts of liquid fertilizers. It should be noted that the same management techniques that reduce input costs also have a net positive environmental impact by conserving water and reducing soil erosion.

Project Outreach

Scenic Valley Farms has created several pages on our company website that detail the progress of the project in both Rosemount and Readstown. The visitor is able to access data collected throughout the growing season and images of various aspects of the project. We have also prepared a monthly newsletter that is distributed to more than 200 recipients. At the conclusion of 2010, we developed a presentation for the Minnesota Fruit and Vegetable Grower's Association annual conference. Additionally, the presentation will be posted on the company website. Throughout the growing season, we hosted individual and small group tours for local growers of the blackberry high tunnel. Key members of the area Amish community were particularly interested in the project and several have either completed or plan to begin construction of high tunnels to produce blackberries.

Future Research and Development

In the next year, we intend to monitor the 2nd year yields of thorn less floricane blackberries. Temperature data loggers have been installed in the high tunnels, and we will utilize these measurements to make connections between average and maximum lows and their effect on yields.

We have also installed a solar thermal high tunnel. The system works by capturing the energy of the sun and releasing it to moderate temperatures. Throughout the day, thermostatically controlled intake fans draw heated air from near the peak of the high tunnel and store the energy below ground in a thermal mass. When supplemental heat is needed to maintain optimal growing conditions, these same fans pull the cooler air through the thermal mass where it is warmed before circulating back into the high tunnel.

We will record and evaluate results compared to a control tunnel. Based on a similar system installed in northern Minnesota, we project being able to set tomato seedlings by March 15h and blackberry root stock by early to mid April. Additionally, we will apply for funding for the technology through the US Treasury 1603 Renewable Energy Grant, USDA REAP Grant and WI Focus on Energy

Other research for next year includes investigating the use of drip tape, various types of organic inline fertilizers, methods to reduce plant foliage, and using leaf tissue analysis to determine nutritional management for the brambles. Besides leveraging the elevated temperatures in the solar thermal high tunnel, we also intend to delay blackberry fruiting by pruning in order to extend the growing season.

We also intend to erect several tomato trellising systems (Florida weave, woven wire cages, A-frame trellis with strings, three panel support) and monitor the plant growth, ease of pruning, yields, and costs associated with each.

In the coming year we also intend to investigate the feasibility of piping waste heat from anaerobic digesters to nearby high tunnels in order to extend the growing season. Additionally, the decontaminated waste products can be converted into a nitrogen-rich fertilizer.

In the coming year, a major focus of our company will be developing Sustainable High Tunnel Agriculture merged with Renewable Energy (SHARE) Farms that are owned by both investors and family farmers. Each SHARE Farm compromises four main technologies: high tunnels, subterranean solar thermal

heating, small wind turbines, and the Environmental Management System (EMS). The EMS is a fully automated and integrated high tunnel climate control system. We consider the system vitally important to commercializing the blackberry industry in the Upper Midwest and will continue to seek funding for development and testing.

Management Tips

1. If annual and perennial weeds are problems where you plan to erect a high tunnel, we recommend using a layer of 6 mil black plastic to smother and kill the weeds and roots. This will allow planting in 2-3 months.
2. Laying black polyester material between the rows is the most effective weed management technique. We recommend though leaving sufficient space between the material and the base of the plant in order to allow new canes to form.
3. The elevated temperatures in the high tunnel allowed the fruit on the Prime Jim and Jan to properly mature and continue blossoming through mid-November (when supplemental heat was discontinued).
4. Be careful to monitor and manage internal temperatures. Attempt to keep the temperatures inside the optimal range of 80-85 °F. High temperatures increase the risk of improper drupelet formation.
5. This year we substituted Japanese koi fish waste with liquid fertilizer containing bat guano. The switch appeared to have little effect on the brambles, as the average size of the primocane blackberries remained roughly the same.
6. Do not use fish emulsion based liquid fertilizer in a drip irrigation system with emitters as it will clog them.
7. When ordering brambles such as blackberries, order plants early, no later than February.
8. Using mulch for winter protection for 'Doyle' has had limited success on cane winter survivability in zones 4 and 5.
9. During high tunnel construction ensure that the connectors which attach the end bows to the purlins are secured with tek screws and wrapped with duct tape. Otherwise the purlins will rip the plastic.
10. Continually pruning of Prime Jim and Jan resulted in continual blossoming.
11. Partial shade negatively effects plant development.

Recommendations for Enhancing Project Benefits

1. Increase level of automation in the high tunnel to minimize human error and further reduce overall input costs
2. Form consortium of local blackberry growers to reduce shipping costs and achieve more bargaining power in the marketplace. A couple of Amish growers in the region have installed high tunnels with the intention of producing blackberries and several other growers intend to erect high tunnels this spring.
3. Research and pursue direct market opportunities in the region to secure higher prices and reduce shipping costs for the fresh blackberries
4. Research, develop, and market the medicinal (specifically anti-oxidant) blackberry properties
5. Develop practices and procedures to harvest, pack, and transport the berries to market

Cooperators

Terry Nennich, University of Minnesota Extension, Crookston, MN

Brad Becker, Dakota County SWCD, Farmington, MN
Craig Gundacker, Scenic Valley Farms, Rosemount, MN
Rebecca Harbut, University of Wisconsin, Madison, WI
Kathy Demchak, Penn State University, University Park, PA

Project Location
From Madison take Hwy 14 to Readstown. Turn right on Hwy 131. Drive approximately .75 miles. Turn right at McCarty Road. Drive approximately 1.3 miles. Turn left at Song Bird Lane (unmarked—look for the high tunnels).

Other Resources
High Tunnels website sponsored by Kansas State Research and Extension, University of Missouri Extension, and University of Nebraska Cooperative Extension
www.hightunnels.org/

Nennich, T., David Wildung, and Pat Johnson. 2004. Minnesota High Tunnel Production Manual for Commercial Growers
www.extension.umn.edu/distribution/horticulture/M1218.html

Safley, C. D., O. Boldera, and G. E. Fernandez. 2006. Estimated Costs of Producing, Harvesting, and Marketing Blackberries in the Southeastern United States. HortTechnology 16: 109-117.
www.ncsu.edu/project/berries/extension/blackberry_budget.pdf

University of Minnesota High Tunnel Production Website
http://hightunnels.cfans.umn.edu

Raspberry and Blackberry High Tunnel Production Guide
http://www.fruit.cornell.edu/Berries/bramblepdf/high_tunnel_production_guide.pdf

Pruning and Trellising Brambles:
http://agresearch.umd.edu/RECs/WREC/files/MDBayAreaBramble%20Pruningv2%202-18-09-Demchak.pdf

Growing Raspberries and Blackberries in a High Tunnel – Iowa State University:
http://www.extension.iastate.edu/NR/rdonlyres/BA5DB27B-4472-4D15-89A0-185DD532C4DF/95187/Hitunnel09.pdf

Cultivar: Natchez

Location: High Tunnel #1 in Readstown, WI

	Planted 6/10/2010	7/10/2010	7/20/2010	8/6/2010	8/15/2010	8/26/2010	9/2/2010	9/10/2010	9/18/2010	9/25/2010	10/3/2010	10/12/2010	10/20/2010	10/29/2010	11/8/2010	12/1/2010	12/24/2010
Branches		2	2	3	4	5	5	6	7	8	8	8	9	9	9		
Sturdiness		medium	medium	strong	strong	strong	strong	strong	strong	strong	strong	strong	strong	strong	strong		
Height (inches)	11	16	19	22	23	27	27	29	31	33	34	35	37	37	37		
Blossoms	0	0	0	some	some	some	0	0	0	0	0	0	0	0	0		
Irrigation Levels (gallons per day)	4	4	4	4	4	4	4	4	4	4	4	4	4	8	8	Soil moisture 40% and soil temp 36F	Soil moisture 39% and soil temp 30F
Insects	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none		
Disease	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none		
Color of fruit	N/A	N/A	N/A	N/A	N/A	a few	a few	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Weight of fruit	N/A	N/A	N/A	N/A	N/A	5 grams	5 grams	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Flavor	N/A	N/A	N/A	N/A	N/A	sweet	sweet	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Yield	N/A	N/A	N/A	N/A	N/A	a few	a few	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		

Cultivar: Ouachita

Location: High Tunnel #1 in Readstown, WI

	Planted 6/10/2010	7/10/2010	7/20/2010	8/6/2010	8/15/2010	8/26/2010	9/2/2010	9/10/2010	9/18/2010	9/25/2010	10/3/2010	10/12/2010	10/20/2010	10/29/2010	11/8/2010	12/1/2010	12/24/2010
Branches	2	3	3	4	5	5	8	9	9	10	10	11	11	12	12		
Sturdiness	medium	medium	medium	strong	strong	strong	strong	strong	strong	strong	strong	strong	strong	strong	strong		
Height (inches)	10	11	13	14	18	22	30	36	38	40	42	44	44	44	44		
Blossoms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Irrigation Levels (gallons per day)	4	4	4	4	4	4	4	4	4	4	4	4	4	6	6	Soil moisture 40% and soil temp 36F	Soil moisture 39% and soil temp 30F
Insects	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none		
Disease	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none		
Color of fruit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Weight of fruit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Flavor	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Yield	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		

Cultivar: Apache

Location: High Tunnel #1 in Readstown, MN

	Planted 6/10/2010	7/10/2010	7/20/2010	8/6/2010	8/15/2010	8/26/2010	9/2/2010	9/10/2010	9/18/2010	9/25/2010	10/3/2010	10/12/2010	10/20/2010	10/29/2010	11/8/2010	12/1/2010	12/24/2010
Branches	1	2	3	4	4	5	7	9	10	11	12	12	13	13	13		
Sturdiness	weak	weak	medium	medium	medium	medium	strong	strong	strong	strong	strong	strong	strong	strong	strong		
Height (inches)	8	17	18	20	21	21	23	29	33	35	40	42	42	43	43		
Blossoms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Irrigation Levels (gallons per day)	4	4	4	4	4	4	4	4	4	4	4	4	4	6	6	Soil moisture 40% and soil temp 36F	Soil moisture 39% and soil temp 30F
Insects	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none		
Disease	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none		
Color of fruit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Weight of fruit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Flavor	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Yield	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		

Cultivar: Arapaho

Location: High Tunnel #1 in Readstown, WI

	Planted 6/10/2010	7/10/2010	7/20/2010	8/6/2010	8/15/2010	8/26/2010	9/2/2010	9/10/2010	9/18/2010	9/25/2010	10/3/2010	10/12/2010	10/20/2010	10/29/2010	11/8/2010	12/1/2010	12/24/2010
Branches	3	4	5	5	7	8	9	12	13	14	14	15	15	15	15		
Sturdiness	medium	medium	medium	medium	strong	strong	strong	strong	strong	strong	strong	strong	strong	strong	strong		
Height (inches)	20	37	39	44	49	51	55	60	62	64	66	68	68	70	70		
Blossoms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Irrigation Levels (gallons per day)	4	4	4	4	4	4	4	4	4	4	4	4	4	6	6	Soil moisture 40% and soil temp 36F	Soil moisture 39% and soil temp 30F
Insects	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none		
Disease	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none		
Color of fruit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Weight of fruit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Flavor	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Yield	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		

Cultivar: Navaho

Location: High Tunnel #1 in Readstown, WI

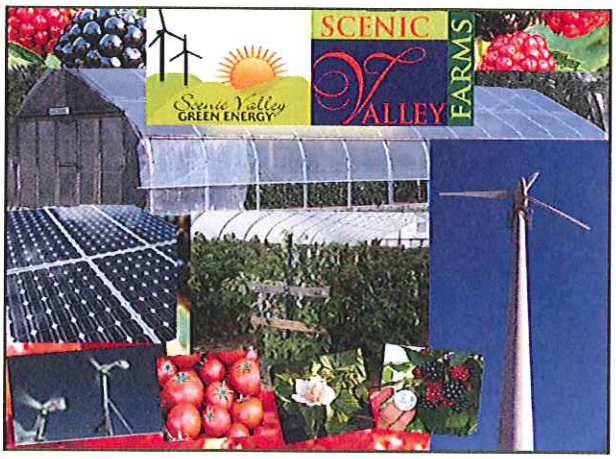
	Planted 6/10/2010	7/10/2010	7/20/2010	8/6/2010	8/15/2010	8/26/2010	9/2/2010	9/10/2010	9/18/2010	9/25/2010	10/3/2010	10/12/2010	10/20/2010	10/29/2010	11/8/2010	12/1/2010	12/24/2010
Branches	2	2	3	4	4	5	6	8	9	9	10	10	11	11	11		
Sturdiness	medium	medium	medium	medium	medium	medium											
Height (inches)	9	11	12	13	13	15	19	23	26	28	34	36	38	38	40		
Blossoms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Irrigation Levels (gallons per day)	4	4	4	4	4	4	4	4	4	4	4	4	4	6	6	Soil moisture 40% and soil temp 36F	Soil moisture 39% and soil temp 30F
Insects	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none		
Disease	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none		
Color of fruit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Weight of fruit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Flavor	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Yield	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		

Cultivar: Chester

Location: High Tunnel #1 in Readstown, WI

	Planted 6/30/2010	7/10/2010	7/20/2010	8/6/2010	8/15/2010	8/26/2010	9/2/2010	9/10/2010	9/18/2010	9/25/2010	10/3/2010	10/12/2010	10/20/2010	10/29/2010	11/8/2010	12/1/2010	12/24/2010
Branches	1	1	2	2	2	3	3	3	3	3	3	3	3	3	3		
Sturdiness	slight	slight	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium		
Height (inches)	9	11	12	13	13	15	24	26	29	30	33	35	35	37	37		
Blossoms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Irrigation Levels (gallons per day)	4	4	4	4	4	4	4	4	4	4	4	4	4	6	6	Soil moisture 40% and soil temp 36F	Soil moisture 39% and soil temp 30F
Insects	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none		
Disease	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none		
Color of fruit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Weight of fruit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Flavor	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
Yield	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		

Producing High Tunnel Blackberries in Zone 4



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Agenda

1. Project Objectives
2. High Tunnel Construction
3. Bramble Spacing and Varieties
4. Soil Preparation
5. Irrigation and Fertigation Systems
6. Trellis System
7. Bramble Management
8. Fruiting Period
9. Growth Characteristics
10. Winterization
11. Market Potential
12. Blackberry Economics
13. SHARE Farm
14. Solar Thermal Heated High Tunnel

Project Objectives

1) Winter protect blackberry plants
   - Floricane thornless plants suffer substantial loss in zone 5
   - Primocanes cut to ground in winter= zone 5 survival but fruit often ripens too late
2) Increase yields
   - 3 to 5 times above average field yields
   - 2200 pounds per 30x96 high tunnel
3) Reduce input costs
   - Decrease use of pesticides, insecticides
   - Reduce labor cost with semi-automated high tunnel
4) Improve Berry Quality
   - Higher percentage grade A blackberries

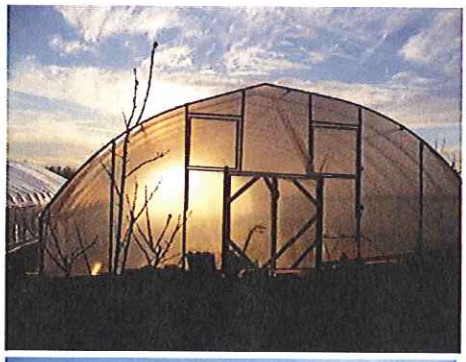
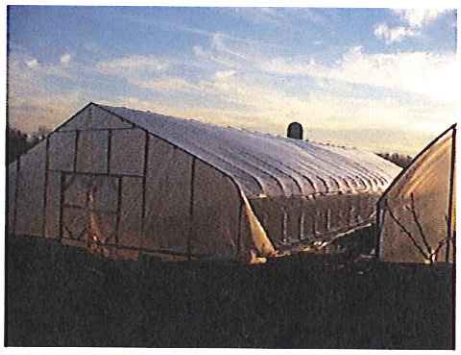
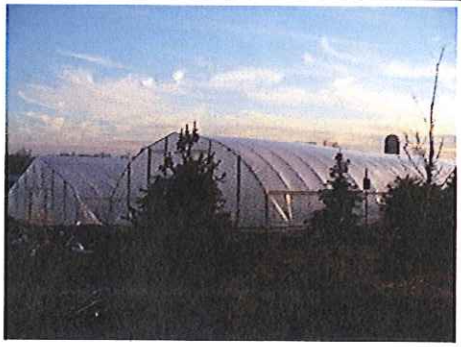
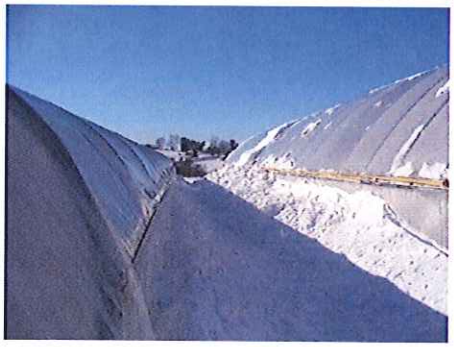
High Tunnel Construction

- Tunnel selection
  - Compared tunnels from FarmTek, Poly-Tex, Atlas, handmade pvc
- Site preparation
  - Gently sloping land selected
  - Plowed and disced (wait at least a year to kill weeds)
  - Used black plastic to heat soil to destroy weeds

High Tunnel Comparison

30'x96'	Poly-Tex	FarmTek	FarmTek	Atlas	PVC
	FieldPro Gothic	Quonset	Gothic	SnowArch	Handmade
Cost/sq ft uninstalled	$2.45	$2.03	$1.98	$2.52	$1.00
Strength	3	2	2	3	3/4
Ease on installation (hardest=3)	1	2	3	3	2
Plastic Mfr.	GreenTek - 3	HTek -2	HTek – 2,	Klerks - 2	GreenTek-3

- The HTek is lighter weight plastic and appears less durable
- The FarmTek gothic high tunnel does not shed snow easily
- The FarmTek gothic style high tunnel is more labor intensive because tek screws are required in each purlin/bow connector
- The FarmTek quonset style high tunnel zippered ends tend to break
- FarmTek gothic plastic is loose fitting on straight bow sections

High Tunnel Construction

- Tunnel layout
  - End of tunnel facing prevailing wind, east to west
  - Side walls oriented south to maximize solar radiation
  - Pound single corner stake into ground and use 3-4-5 ratio to square other corners 30' and 96' on center
  - Attach string line at desired top of ground post and another string line 6" beneath.
  - Pound remaining post approx 2' in ground/1' above ground
- Tunnel construction
  - Follow directions provided by manufacturer
  - Helpful hints:
    - Use string line and 1 ¼" tek screws set into stakes when sliding bows onto ground stakes
    - Use tek screws to secure connectors to bows and end of purlins
    - Duck tape all purlin connections at end of bows
    - Use 1x6 pine boards for curtain and base boards and drill 1 ¼" tek screws to secure to bow
    - Install u-channel and wiggle wire on side walls
    - Install plastic on calm morning or evening (< 5 mph)
    - Attach plastic to 5 -2x4 x12' lengths of lumber and pull over side walls
    - Allow at least three hours of calm wind to secure plastic

Bramble Spacing and Varieties

- Spacing in High Tunnel
  - Four rows per 30' wide tunnel
  - Each row 7'apart and 4 ½' from side walls
  - Brambles 3' apart with 132 plants per 30'x96' tunnel
- Bramble Varieties
  - Primocane (thorny) – Prime Jim and Jan
  - Floricane (thornless) Arapaho, Apache, Natchez, Navaho, Chester, Triple Crown, Ouachita, Doyle

Soil Preparation

- Composted ½ mushroom compost and ½ dairy manure
- Mixed one wheelbarrow per ten foot of row and tilled into soil
- Perform soil nutrient analysis
- Mulched around plants with mushroom compost or straw

Irrigation System

- Installed drip irrigation
  - Emitters within 8" on either side of bramble
  - Each emitter releases ½ gallon per hour.
- Semi automated system
  - Sensor and controller provide 6 zones with 6 irrigation times per zone
  - Sensor provides moisture content (%), soil temperature, and EC
  - Irrigation cycle suspended above pre-set soil moisture content
  - Irrigated in 1.5 hour cycles at 7 am and 6 pm
  - Irrigation increased to three 1.5 hour cycles during fruiting

Fertigation System

- Installed EZ Flow (1 gallon) inline fertigation system
- Applied organic liquid fertilizer containing bat guano
  - FoxFarm Big Bloom, Pure Blend Pro Bloom
- Discovered fish emulsion based fertilizer clogs emitters
  - Drip tape not clogged by emulsion but emitters too close = wasted water and fertilizer
  - Plan to install drip tape next year in two rows of single tunnel. These two rows will have separate moisture sensor, valve and fertigation tank
  - Plan to fertigate 2-3 times per week

Weed Management

- Three Techniques Employed:
  1. Wood chips in small PVC high tunnel
  2. Layer of cardboard boxes and wood chips spread on top in gothic style high tunnel
  3. Black polyester material (14-24 mil) in 3' and 6' wide sections
- Polyester generally most effective and least labor intensive

Trellis System

- Modified V/T system with bottom "T" 36" and top "T"66" above ground
- Run two strands of wire at tip of each crossbar
- Alternative: 4x4 non treated posts that are notched. Insert 2x4 "T"s
- Space posts 10' apart
- Year 1 canes tied to one side of the strand and will bear fruit in year 2
- Fruit bearing year 2 canes will be pruned to ground to make room for the year 3 primocanes.

Bramble Management

- Pruned Prime Jim and Jan to ground in winter.
- Tip when new canes reach five feet in summer
  - New blossom supporting laterals appear within weeks
  - Continual pruning generates new blossoms
- Tie floricanes to wire trellis. Tip at 6'. Tie laterals to wires.

Fruiting Period

- Primocanes
  - Fruiting began early August
  - Blackberries averaged 6-15 grams
  - Temperatures over 100° F hindered druplet formation
  - Brambles consumed large amounts of water
  - Difficult to harvest berries at optimal ripeness due to softness
  - Thorns required gloves and heavy flannel shirt
  - Last harvest on Nov 18th (turned off supplemental heat)
    - Numerous berries and blossoms still remained on plant
  - Total yield from 12x40' tunnel = 75 pounds
- Thornless Floricanes
  - Chester, Apache, and Arapaho bore small quantities

The blackberries on November 14th

Fruiting Period

The blackberries on November 14th

Growth Characteristics

- Brambles not shaded in Wisconsin →
  - studier canes
  - experienced faster growth
  - developed more laterals
- Higher blossom counts and yields on primocanes in west vs. east end of high tunnel due to two extra hours of direct sunlight
- Better growth on root stock vs. culture stock
- Inconsistent growth of same variety frequently observed

Winterization

- Winter Protection →
  - Installed thermostatically controlled 170,000 BTU propane heater that fires at 5° F and deactivates at 9 ° F (minimum temperatures of zone 7b climate)
  - Forcing dormancy is lengthy process due to elevated temperatures and snow insulation
- Pest Issues
  - Rabbits girdled floricanes over several days
  - Trapped the critter but would have destroyed crop in two weeks or less
  - Rabbits avoided primocane variety
- Final irrigation cycle on November 7th
  - Heavily watered previous week
  - No moisture over winter is a concern
- Elevated February temperatures may promote premature budding.
  - Plan to ventilate high tunnel and monitor signs of budding.

Market Potential

- Wholesale food dealers usually pay $5-6/lb. organic June 1 thru Nov. 30
  - Potential Dealers: Sun Belle Inc, Bergin Fruit and Nut Company, Organic Valley Farms
- Direct Market
  - Supermarkets/Retail Outlets
  - Grocer Cooperatives
  - Restaurants
  - Farmers Market's ≈ $3.50 a half pint (6 oz)
- Community Supported Agriculture (CSA)
- Value Added Products (e.g. jams, jellies, pies, candies)
- Schools and Universities

Economics

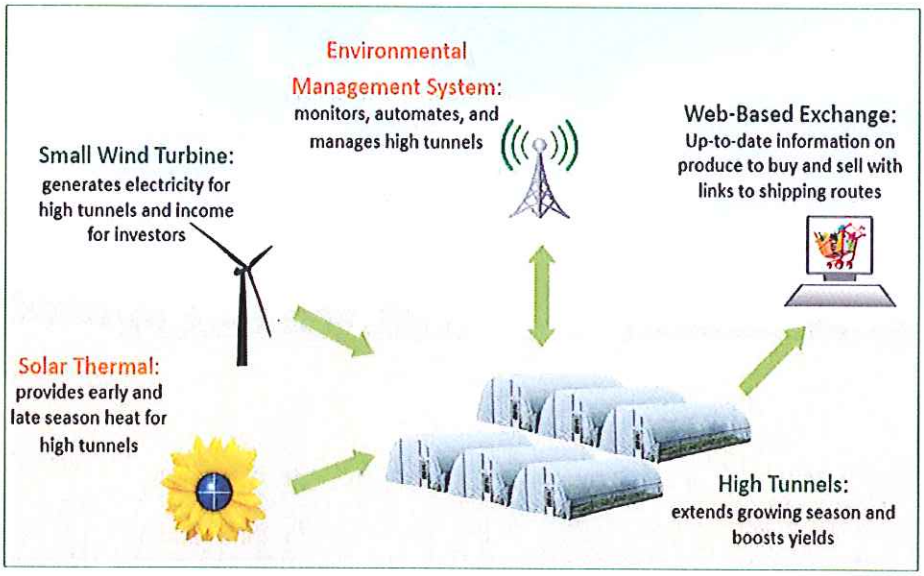
	Expense	In come
High tunnel (30'x96') *not including installation	$6500	
Irrigation and controller, trellis, fertigation tank	$1400	
Blackberry plants	$300	
End walls, side boards, door hardware, screws	$700	
Motorized rollup sides w/thermostat	$1000	
Heater w/thermostat	$350	
Ventilation fan & shutters w/thermostat	$550	
Packaging and shipping products	$400	
Income (1800#s per tunnel at $6/#, 50/50 wholesale & retail)*		10800
Total	$11200	$10800

*production levels reached in year three

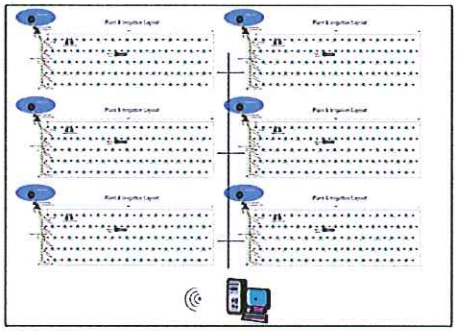
Future Tasks

- Record 2nd year yields of thornless floricane blackberries
- Develop practices and procedures to harvest, pack, and transport the berries to market
- Solar thermal high tunnel
  - Record and evaluate results compared to control tunnel
  - Apply for funding through US Treasury 1603 Renewable Energy Grant, USDA REAP Grant and WI Focus on Energy
  - Expect solar thermal ht to add 1.5 months to the season beginning and ending vs unheated ht
- Next year's research
  - Conduct research on raspberries, peppers and heirloom tomatoes
  - Experiment with drip tape
  - Determine nutritional management through leaf tissue analysis
  - Apply various organic inline fertilizers
  - Investigate methods to reduce plant foliage
  - Develop season extension practices →
    - delay fruiting by pruning
    - plant earlier in solar thermal high tunnels
  - Compare tomato staking systems (Florida weave, woven wire cages, A-frame trellis with strings, three panel support)
    - Monitor plant growth, ease of pruning, yields, and costs
- Study feasibility of merging anaerobic digester and high tunnel technology →
  - Provide heat for high tunnels
  - Incorporate by-products as fertilizer and mulch
- Conduct research on using compost to generate heat in high tunnel
- Continue to automate growing process
- Develop Sustainable High Tunnel Agriculture merged with Renewable Energy (SHARE) Farms

Investor Owned Sustainable High Tunnel Agriculture + Renewable Energy (SHARE) Farms



Environmental Management System (EMS)



- A PC based system that monitors, automates, controls and manages the high tunnel environment
- Sensors connected to a Programmable Logic Controller (PLC)
- PLC wirelessly connected to a PC
- Scalable with additional high tunnels

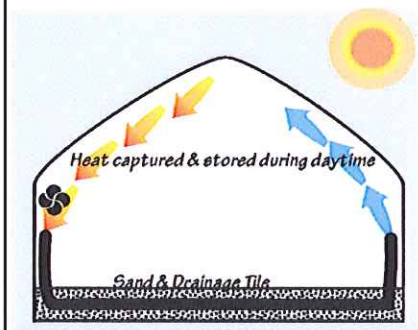
High Tunnel Sensors

air temperature
soil temperature
humidity
soil pH
soil water content
TDS/EC
light intensity
motion
video
water flow

Production Processes Controlled

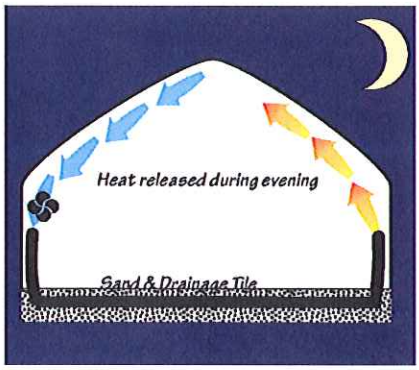
heating
cooling
ventilation
circulation
irrigation
fertigation
security
surveillance

Solar Thermal Heating



- Federal Investment Tax Credit or Renewable Energy Grant (30%)
- USDA Renewable Energy for America Program (proposed)

- EMS controlled circulation fan captures heated air from high tunnel during day
- Solar thermal mass releases heated air at night when required
- Extends growing season to allow for additional crops and harvests
- Eliminates propane fuel and greenhouse gas emissions



Small Wind Energy

Overview

- Turbines of 100 kW or less in size
- Generates electricity for SHARE farms
- Creates income from excess electricity
- Solid, long-term investment
- Investors receive federal, state, and utility grants
- Offsets investors' tax liabilities
- Eliminates operational C02 emissions

Incentives

- Federal Investment Tax Credit or Grant (30%)
- USDA Rural Energy for America Program (25%)
- Accelerated Depreciation (30% for 30% tax bracket)
- Wisconsin Small Renewable Energy System Grant (25%)
- Electric Utility Grants (varies)
- Sale of excess electricity (≤ 40 kW)

Open Web-Based Exchange

- Designed for wholesale buyers, regional producers, and shipping services in Southern Wisconsin
- Provides up-to-date information on type, grade, quantity, availability and price (optional) of both available and desired produce
- Provides links to freight routes, schedules and common carriers
- Open to registered users who complete a profile
- Operates initially at a regional level before potentially expanding

SHARE Financial Information

Projected numbers based on anticipated incentives and yields	*Blackberries* Solar Thermal High Tunnel (3) 20 kW wind turbine	*Tomatoes* Solar Thermal High Tunnel (3) 20 kW wind turbine	*Blackberries* Solar Thermal High Tunnel (14) 40 kW wind turbine	*Tomatoes* Solar Thermal High Tunnel (14) 40 kW wind turbine
Cost				
Installation	$275,000	$273,000	$875,000	$865,000
Variable	$13,000	$16,000	$55,000	$57,000
Fixed	$7,000	$7,000	$31,000	$31,000
Incentives	$140-$230,000	$140-$230,000	$440-$720,000	$440-$720,000
Revenue	$44,000 @ $5.80/lb	$40,000 @ $1.25/lb	$199 K @ $5.80/lb	$179 K @ $1.25/lb
Net profit*	$24,000/yr	$17,000/yr	$113,000/yr	$91,000/yr
Financial Payback**	3-6 yrs after full production	3-8 yrs	2-4 yrs after full production	2-5 yrs
Annual Return on Investment (ROI)	10-14%	8-10%	15-18%	12-14%
	*Net profit after payback includes income from HT and wind turbine	**Assumes wind and solar thermal implemented		